OBITUARY NOTICES

OF

FELLOWS DECEASED.

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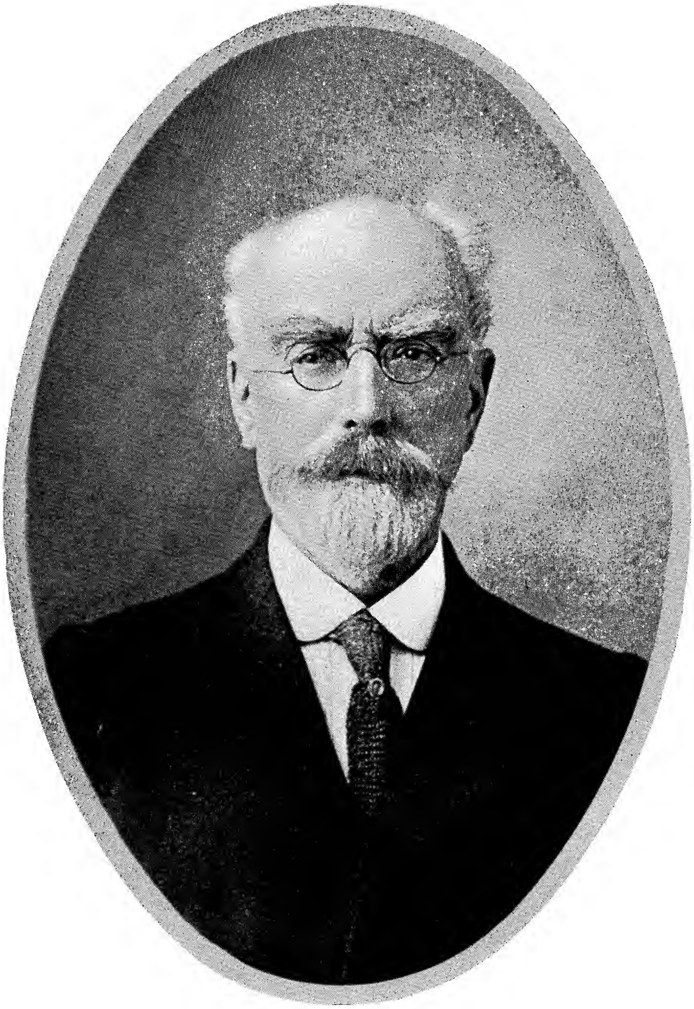


G. Lippmann

GABRIEL LIPPMANN, 1845–1921.

Gabriel Lippmann was born near Luxemburg, his father being a native of Lorraine and his mother an Alsatian. He received his early education at home, and when his parents settled in Paris, entered the "Lycée Napoléon" at the age of thirteen. Ten years later he was admitted to the Ecole Normale.

Lippmann's pronounced individuality, which appeared so strongly, both in the subjects he selected for research and in his method of attacking problems, showed itself at an early age; but the boy, absorbed in his own thoughts and irresponsive to outside influence, was not marked out for a successful school career. Concentrating on what interested him, neglecting what did not appeal to his taste, he acquired an invaluable fund of useful but unremunerative knowledge, with the result that he failed in the examination of "agrégation," which would have qualified him for Government service as a teacher in one of the higher schools. His exceptional abilities could not, however, fail to impress the more discriminative of his masters, and while still *in statu pupillari* Bertin induced him to collaborate in the publication of the "Annales de Chimie et de Physique" by abstracting German papers. It was in this way that he first became acquainted with contemporary researches on electricity, a subject which was not then taught at the Sorbonne. He is reported to have drawn Ruhmkorff's attention to the desirability of synchronizing the periods of the primary and secondary windings of an induction coil, but the "business man," as frequently happens, was not amenable to the advice of an academic novice.

After his failure in the examination, those who knew Lippmann and were able to appreciate his great abilities had, fortunately, sufficient influence with the Government to secure for him the appointment to a scientific mission, which gave him the opportunity of visiting German institutions and studying the provisions there made for the teaching of science.

At Heidelberg, the Professor of Physiology, Kühne, showed him a well-known experiment, in which a drop of mercury, covered by dilute sulphuric acid, is seen to contract on being touched with an iron wire, and to regain its original shape when the wire is removed. Lippmann recognised that the effect must be due to a connection between electric polarization and surface tension. He obtained permission to conduct, in Kirchhoff's laboratory, a systematic investigation of the subject, and was thus led to the construction of the capillary electrometer, an instrument now in daily use.

In 1883, Lippmann was appointed Professor of Mathematical Physics in the Faculty of Science at Paris. Three years later he succeeded Jamin as Professor of Experimental Physics, and became Director of the Research Laboratory which was subsequently transferred to the Sorbonne. He retained this position until his death.

Apart from his work on electro-capillarity, Lippmann obtained his most notable success in connection with colour photography. In a communication

published in the "Revue des Sciences pures et appliquées," to which the writer of this notice is much indebted, M. A. Leduc states that as early as 1886 he explained in his lectures the general theory of the process by which the reproduction of colours by photography could be obtained. In the light reflected by a mirror the incident and reflected rays form together what in acoustics are called stationary vibrations, the planes of equal intensity being parallel to the mirror, and the distances between the maxima and minima proportional to the wave-length. If the mirror be covered by a sensitized film, layers are consequently formed in which the amount of deposited silver alters periodically. The principle when once stated is simple, but the practical execution presented difficulties that demanded all the patience and skill of an accomplished experimenter.

In a short communication to the "Académie des Sciences" in Paris, in 1891, Lippmann pointed out the two conditions which were essential to the successful application of the method. In the first place, the deposit of silver must be continuous or, at least, any granules formed must be small compared with the wave-length of light. The second condition demands an optical contact between the film and a good reflecting surface, which can best be secured by using mercury as the reflector. In practice, the glass plate carrying the film is attached to a hollow dish that can be filled with the liquid metal. After exposure, the mercury can be removed and the plate developed in the ordinary way.

The photographs obtained in this manner were at first defective, owing to the varying sensibility of the photographic film for different parts of the spectrum. Lippmann could report some improvement in the following year, and in 1893 he presented to the Académie des Sciences photographs taken by MM. Auguste and Louis Lumière, in which the colours were reproduced with perfect ortho-chromatism. An interesting variation of the process is described in another communication ('C. R.,' vol. 115), where it is shown that films impregnated with bichromate of potash are modified by the action of light which renders it less hygroscopic. The subsequent absorption of moisture affects the refractive index and an optically periodic layer is thus obtained. The complete theory of the reproduction of compound colours was published by Lippmann in 1894, but its essential points are contained in a paper by Lord Rayleigh, published in the 'Philosophical Magazine' in 1887, in which the author suggested that laminated structures produced by stationary luminous waves might explain the reproduction of coloured spectra such as were obtained by Edmond Becquerel as early as 1848.

Lippmann's scientific output, measured in pages of print, was not extensive; his communications to the Académie des Sciences were short, but invariably contained some original idea and illuminated the essence of his subject. As a member of the Board of the Bureau des Longitudes his attention was drawn to the exact measurement of time, and his contributions towards the perfection of experimental methods were always of interest and sometimes of considerable value. He realised at an early date the great assistance of

photographic registration, and an ingenious method of eliminating the personal equation in measurements of time was published in 1895. He dealt with the question of getting rid of the irregularities of pendulum clocks ('C. R.,' vol. 122, 1896), and his device for comparing the times of oscillation of two pendulums of nearly equal period ('C. R.,' vol. 124, 1897), deserves greater attention than it has received. His most important contribution to Astronomy was the invention of the cœlostat. In the so-called siderostats, which are in general use, the image of a star can be made to remain stationary while the star itself pursues its diurnal motion, but at the same time the images of surrounding stars partake of a rotational motion round the central point. This is entirely avoided in the cœlostat, so that an area in the sky of finite extension can be reduced to rest for a sufficient time to allow a lengthened photographic exposure.

Like most men of original mind, Lippmann was much absorbed in his own thoughts, and sometimes went over ground that had already been covered by others; occasionally one finds cause for regret that he appeared to lose interest in a subject when he had surmounted its difficulties, but before his work could be readily utilised by others. It is nevertheless of interest that in 1905 he independently enunciated the principle of the isostacy of the earth's crust ('C. R.,' vol. 136, p. 1172), and that two years later he described, under the title of 'Thermoendosmose des gaz,' an interesting phenomenon first discovered by Osborne Reynolds.

Attention may also be drawn to a few of his many ingenious devices which may prove useful, though some of them require further elaboration in detail. In 1901 Lippmann described a new form of galvanometer, which could be made absolutely astatic ('C. R.,' vol, 132, p. 1161). In 1902 he showed how small changes in the level of a mercury surface could be observed to a higher degree of accuracy than by the methods in common use ('C. R.,' vol. 135, p. 831); in 1910 he obtained a perfect electric connection that did not require the application of any pressure at the point of contact ('C. R.,' vol. 158, p. 1015). A new form of seismograph giving directly the acceleration of the earth's movement (described in 1909) is not only of theoretical interest, but may have a great future in its practical application ('C. R.,' vol. 148, p. 138). Its main principle consists in giving to a source of light a movement depending on the velocity and acceleration of the earth's motion and observing the image through a lens attached to the weight of a pendulum. Lippmann showed how the adjustments can be made so as to register the correct acceleration, but does not indicate how far he had tested the method.

Lippmann was elected a Foreign Member of the Royal Society in 1908, and was awarded the Nobel Prize in 1908. He died on July 31st, 1921, on board ship, during his return from a journey to Canada and the United States, in which he took part as a member of the mission sent out by France under the leadership of Maréchal Fayolle.

A. S.

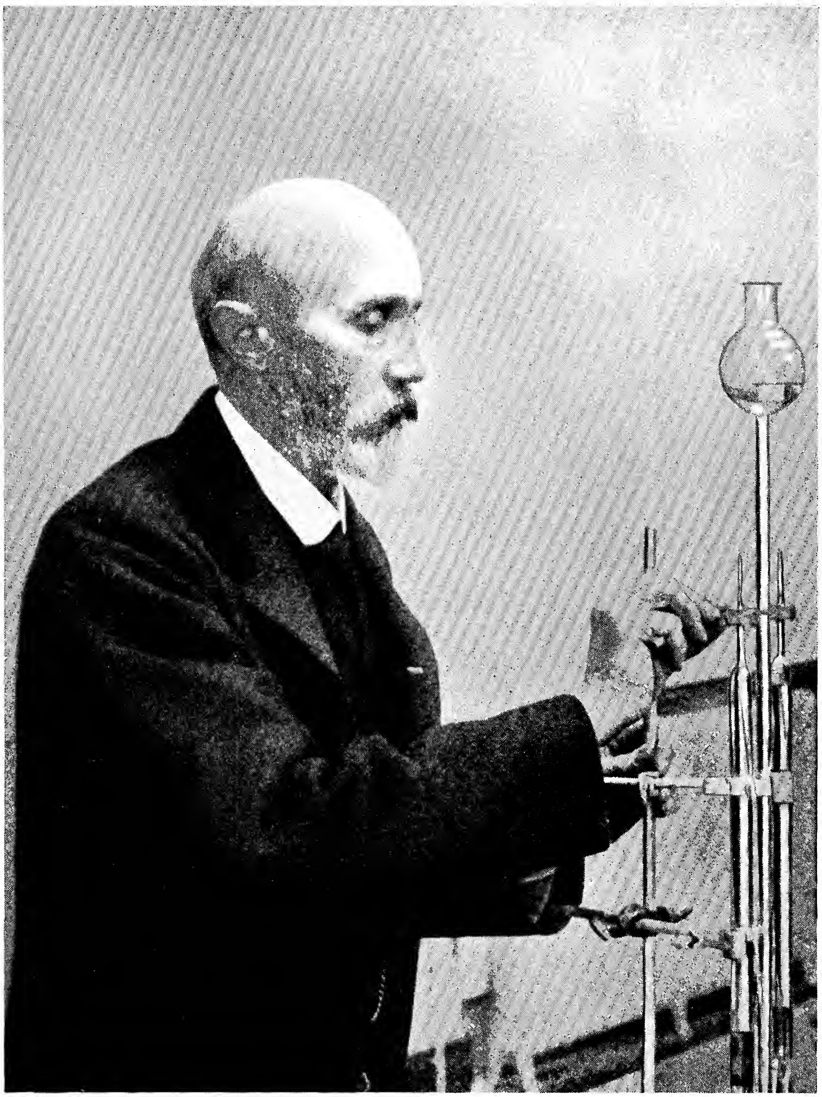
THOMAS PURDIE, 1843–1916.

Some centuries hence, when the present time and the Great War with which it has been overwhelmed can be seen in their true perspective, interest may be aroused as to how this country was almost suddenly able to produce enormous amounts of divers chemical materials, in the previous manufacture of which it had little or no experience. It will then perhaps be understood, as it is certainly but little realised now, that this memorable achievement was only rendered possible through the circumstance that at our universities and other academic institutions there had been for a generation before a small body of men, who, subsisting on very inadequate salaries and without any prospect of other worldly recognition, had been devoting themselves in their leisure (for it was not generally regarded as part of their academic duties) to the pursuit of pure chemical research. These men had associated with themselves in their scientific labours a select few of their more promising pupils, to whom they had succeeded in imparting some of their love and enthusiasm for the search after new knowledge for its own sake, and without any idea of recompense as understood by the exoteric public. This devoted band of men had during the generation preceding the war been successful in building up a British School of Chemical Research, which, although limited as regards the number of workers, was perhaps second to none in respect of the quality of its output. It was this school of chemical research, already in being, that rendered possible the supply of advice and of *personnel* necessary for the manufacture of the varied chemical products, without which this terrible war could never have been carried on with any possibility of success by a country the rulers of which, in their complete and unashamed ignorance of science, had taken no adequate steps to provide for.

Amongst the builders of the British School of Chemical Research there was certainly none more ardent or disinterested than Thomas Purdie, who for some twenty-five years occupied the Chair of Chemistry in the University of St. Andrews. The success of his labours is attested by the fact that, amongst the chemists who came to the assistance of the country in the hour of need, some of the most prominent were men who had received their initiation into research as his pupils.

Purdie was born at Biggar, Lanarkshire, on January 27, 1843, his father, whom he lost in early childhood, being a banker in that town. His upbringing devolved mainly on his mother, to whom he was deeply attached, but he was also much indebted in a variety of ways to a childless paternal uncle, a successful Edinburgh business man, whose resources were often placed at the disposal of the nephew, in whose development he took a very real interest.

Purdie received his school education at the Edinburgh Academy, where his literary and classical tastes appear to have been aroused by the



Thomas Purdie

stimulating personality of D'Arcy Thompson, the accomplished Greek scholar and father of the well known zoologist, hellenist, and biological philosopher, the present occupant of the Chair of Natural History at St. Andrews. On leaving school, Purdie, who was intended for a business career, was sent to Spain, where he acquired a sound knowledge of the language, and incidentally became attracted to mineralogy, and this doubtless influenced his choice of a profession later on. After a short experience of commercial life, however, he changed his intentions, and in the early sixties of the last century he embarked with a cousin for South America to take up farming in the Argentine. A large plot of land was purchased by the young pioneers, who established an *estancia*, which, owing to the unsettled state of the country, was the scene of many thrilling adventures, of which Purdie had interesting stories to relate. To those who later only knew him in the laboratory and in the lecture-room, it was difficult to picture this eminently peaceful man carrying on a defensive warfare against the marauding bands of Indians which periodically attacked the farm, and ultimately led to his abandoning the enterprise, in consequence of the financial embarrassment to which these frequent and unwelcome visitations gave rise.

The seven years which Purdie spent in South America, although terminating in failure from the common-place point of view, must have actually been of great value to him in developing his character and in broadening his outlook on life, by bringing him in contact with people, aspects of nature, and social conditions so profoundly different from those to be met with at home. This chapter in his life no doubt served as a permanent corrective to those Philistine influences which were the bane of those exclusively reared in Great Britain during the Victorian era, and it was the freedom from those confining prejudices and conceits which conferred on Purdie much of the charm of his engaging personality. These years had also stirred his scientific interests, for no actively intelligent man can pursue agriculture without being drawn into that logical study of natural phenomena which we call Science, whilst in Purdie's case the flora of the pampas and the geology of the Andes had attracted his special attention.

It was on his return to England that Purdie, now about 29 years of age, had the courage to start on an entirely new career. He used to ascribe his choice to a chance conversation with Huxley, whom he happened to meet under the cliffs at St. Andrews, with which Purdie was already at that time associated through his uncle being the owner of "Castlecliff," the principal residence there. Purdie having made up his mind, put his foot on the bottom rung of the ladder which he was aspiring to scale, and entered as a student at the Royal School of Mines. Here he came under the influence of the teachers by whom that Institution was then adorned—Huxley, Edward Frankland, Guthrie, Percy, and Warington Smyth. That he was a student of distinction is shown by the fact that, on his obtaining the Associateship, he

was, in 1875, appointed by Frankland as one of the Demonstrators in the Chemical Laboratories at South Kensington. It was when acting in this capacity that the present writer, then a second-year student of chemistry, made Purdie's acquaintance.

After spending some four years as a Demonstrator at South Kensington, Purdie decided to widen his chemical and academic horizon by proceeding to Germany, where, in the University of Würzburg, he entered the laboratory of Johannes Wislicenus, to whom at that time Frankland was forwarding those of his pupils who aspired to the acquisition of those finishing touches in chemical training which the atmosphere of a German university was alone capable of imparting.

Purdie went to Würzburg in the winter term of 1878, and a few months later married Miss Marianne Rotherham, of Coventry, who during the remaining thirty-six years of his life was his devoted and constant companion in sickness and in health, and whose personal charm was so largely instrumental in securing the success of his later social activities as an academic teacher at St. Andrews.

Purdie's research work for the degree of Ph.D. was continued at Würzburg until 1880, and during this period of two years the hospitality dispensed at the *ménage* of their married colleague was greatly appreciated by a number of British, American and German students. Amongst these were W. H. Perkin, junr., A. G. Perkin, Dobbin, Leonard Thorne, Burton, Gutzeit, Bischoff, and the writer. The great personal magnetism of Wislicenus exercised a deep and lasting influence on Purdie, not only in stimulating that enthusiasm for research which was so conspicuous to the end of his life, but in revealing to him, as it did to others, how a great department can be successfully directed, granted the possession of a certain personal equipment by the chief, without having recourse to any autocratic prerogative or actual manifestation of authority. Purdie's subsequent career at St. Andrews showed that he possessed in a high degree this personal equipment—unfailing and sympathetic goodwill towards assistants and students, unswerving adherence to justice in all his dealings, together with a quiet dignity as unassailable as it was unprovocative.

Soon after his return to England, Purdie succeeded Dr. Frank Clowes as Science Master at the Grammar School, Newcastle-under-Lyme, in 1881, and it was not until 1884, at the ripe age of 41, that he obtained wider scope for his energies and ability by his appointment to the Chemistry Chair at St. Andrews in succession to Prof. Heddle.

From the very outset it was Purdie's ambition to develop a Chemical Department in which original investigation, carried out both by the Professor and by his assistants and senior students, would form an integral and prominent feature. With the optimism of the idealist, he saw no reason why a Chemistry School such as he had seen in full operation in the small university towns of Germany should not be realisable at St. Andrews. He determined, in fact, to establish at the smallest Scottish university

something which did not exist at the time at the larger and more renowned Universities of Edinburgh, Glasgow and Aberdeen. To achieve this goal Purdie devoted all his energies, both physical and mental, as well as his private resources, nor did he allow himself to be discouraged by numerous disappointments or by the prostration which attended the more and more frequently recurring attacks of asthma, by which distressing malady the later years of his life were overshadowed. His will to succeed where others had failed was so indomitable that he was able to overcome obstacles which would have induced less resolute men to abandon the struggle.

Like a number of Wislicenus' pupils, Purdie was attracted by the problems of stereochemistry, and more especially those relating to optical activity and the asymmetric carbon atom, in the investigation of which Wislicenus had been one of the earliest pioneers. It was in this field that Purdie and his coadjutors laboured so incessantly and with ever-increasing success.

The progress of Purdie's scheme for establishing a School of Chemica. Research at St. Andrews can be followed by a survey of his publications in the 'Transactions of the Chemical Society.' From 1885–87 he appears as a solitary worker, making contributions in his own name only, but from 1888 onwards to 1910 we find his name invariably associated either with those of his assistants or senior students, thus showing that the exotic plant which he had brought with him from Würzburg-on-the-Main had taken root and become acclimatised on the barren shore of St. Andrews Bay. Practically, all these joint contributions have reference to optically active carbon compounds. In this place it will only be necessary to call special attention to two groups of these publications.

It is well known to stereochemists that Pasteur, in his classical researches on optical activity, had at the very outset the good fortune to happen upon the comparatively rare phenomenon of an inactive racemate crystallising not as such but as a mixture in equal quantities of the optically active antipodes. In his first entry into the field of optical activity Pasteur found, in fact, that the optically inactive solution of sodium ammonium racemate yielded crystals which were not homogeneous, but consisted of a mixture in equal quantities of sodium ammonium *dextro*-tartrate and sodium ammonium *lævo*-tartrate respectively, and but for his apparently by chance lighting on this comparatively exceptional phenomenon it seems probable that his subsequent progress in unravelling the fundamental mysteries of optical activity would have been greatly delayed. By availing himself of this discovery Pasteur devised a method for easily obtaining from optically inactive racemic acid the *dextro*-tartaric and *lævo*-tartaric acids of which it is made up; for by preparing a supersaturated solution of sodium ammonium racemate, and introducing a crystal of sodium ammonium *dextro*-tartrate, a crop of crystals of the latter compound is obtained, whilst by introducing a crystal of sodium ammonium *lævo*-tartrate into a similar solution of the racemate a crop of sodium ammonium *lævo*-tartrate crystals makes its appearance. Purdie had the luck to meet with precisely the same phenomenon in the case of the zinc ammonium

salt of inactive lactic acid, and was thus able to effect a simple, speedy, and highly elegant "resolution" of inactive lactic acid into the optically active enantiomorphs or antipodes, *dextro-* and *lævo*-lactic acids, of which it is composed. In this manner these very important active compounds can be readily obtained in large quantity.

The vast edifice of organic chemistry, which, unfortunately, is practically a sealed book to all but those who have pursued a laborious course of study in this branch of science, whilst its fruits have become indispensable to the everyday life of the civilised world, has been reared by the discovery of chemical reactions which, by the possibility of their wide application, enable the most varied arrangements of the atoms in carbon compounds to be brought about. The discovery of such a reaction stands to the credit of Purdie and his pupils, and as is so frequently the case, the discovery was made accidentally in the course of investigations having a totally different objective. Purdie was engaged in the preparation by a well-known method of the esters of certain optically active hydroxy-acids by acting with alkyl iodides on the silver salt of the hydroxy-acid (*e.g.*, lactic or malic acid), with the result that he found that the alkyl lactate or alkyl malate so formed had a considerably higher rotation than when the same compounds were prepared by other methods. This at first he supposed to be due to the compounds of higher rotation being of greater purity than the ones of lower rotation; but before long he discovered that precisely the opposite of this was the truth, and that the products of higher rotation were contaminated in each case by a compound (of high rotation) which had been simultaneously formed by another and hitherto unsuspected reaction between the ingredients used in his experiments. Thus by acting with ethyl iodide on silver lactate he had obtained not only ethyl lactate, but also some ethyl ethoxypropionate, which, having a much higher rotation than ethyl lactate, caused the mixture also to have a higher rotation than that of pure ethyl lactate. Similarly, from ethyl iodide and silver malate he had obtained a mixture of ethyl malate and ethyl ethoxysuccinate, giving a higher rotation than pure ethyl malate. By the further study of this subsidiary reaction, taking place in the above cases, Purdie elaborated a highly important method for the alkylation of hydroxy-compounds in general. This, which in future will doubtless conveniently be designated as the "Purdie reaction," consists in treating the hydroxy-compound, either in the homogeneous state or dissolved in a neutral solvent, with dry silver oxide and alkyliodide, when alkylation of the hydroxy-group is readily effected.

This reaction was at once exploited by Purdie and his pupils in the systematic investigation of those numerous and important hydroxy-compounds which constitute the sugar-group (aldoses, ketoses, polysaccharides, glucosides, etc.). These researches, begun in conjunction with J. C. Irvine and other pupils (R. C. Bridgett, D. M. Paul, R. E. Rose, and C. R. Young), were continued after Purdie's retirement, in 1909, by Irvine, his successor in the Chair, and by him they have been zealously prosecuted up to the present time

with such conspicuous success that they bid fair to form a worthy complement to the earlier monumental work of Emil Fischer.

In speaking of Purdie's pupils mention must also be made of work carried out by some after leaving St. Andrews. Thus, more especially should reference be made to the well-known researches of Prof. Alexander McKenzie, culminating in his discovery of "the asymmetric synthesis," the goal so eagerly striven for by many stereochemists, including Emil Fischer himself.

Further evidence of the vitality of the Chemical School founded by Purdie is afforded by the fact that during the War the St. Andrews Laboratory was one of the most active centres in which those innumerable chemical problems to which the circumstances of that great conflict gave rise were wrestled with and for the most part successfully solved.

Thus before the end of his life Purdie had the satisfaction of seeing the Chemical Department, which his creative energy and resource had raised from the dust and ashes of bankrupt mediævalism, obtaining wide recognition as a focus of fruitful research and performing work of the utmost practical importance to the nation in the hour of its sorest need.

It was not, however, Purdie's intention that the prosperity of this Chemical Department at St. Andrews should terminate with his own life, a precarious one at best, but that it should be, as far as he could ensure it, a permanent establishment capable of holding its own after he had passed away. So loyally was this wish of his carried out by his wife, who survived him only two years, that the residue of her estate, amounting to about £25,000, was, by her will, bequeathed to the University, to be applied exclusively to the promotion of research in chemistry at St. Andrews. This sum, with that made over during Purdie's lifetime, gave a total endowment in 1919 of approximately £33,000 for the prosecution of chemical investigation in the department of which he laid the foundations on his taking up the Chair in 1884. It would surely be difficult to point to any more illustrious example of whole-hearted and enduring devotion to science than is furnished by this record.

We are generally accustomed to associate conspicuous achievements, such as have been described above, with persons of great and manifest vigour, a forceful individuality, endowed with exuberant health and spirits, or with other external signs of available energy; but in Purdie there was none of this. The central fire was wholly concealed by the tall, frail, and somewhat languid figure and placid features, as well as by the modest, retiring, and self-effacing deportment, whilst the melancholy and sympathetic eyes alone would, as occasion demanded, glow with enthusiasm, or twinkle with a sense of humour, mirroring forth the rare soul which dwelt within.

No account of Purdie's work at St. Andrews would be complete without some reference to the social activities which centred around 14, South Street, the charming but modest home in which he and his ideal helpmate dispensed a genuine but unostentatious hospitality to a wide circle of friends, colleagues and students. It was, in the truest sense of the words, an "open house,"

sought for purposes of friendly intercourse, for intellectual discussion, for counsel, and for sympathy in joy or sorrow.

Purdie took his relaxation in golf on the far-famed links, in foreign travel, and in trout-fishing in various remote parts of Scotland, latterly at Finsbay, on the Island of Harris, where both he and Mrs. Purdie will long be remembered for their kindly relations with the crofters.

Purdie's scientific work was recognised by his election to the Fellowship of the Royal Society in 1895, by the LL.D. degree of Aberdeen University, which was conferred on him in 1894, whilst the very special services which he had rendered to St. Andrews were acknowledged by the conferring of the LL.D. degree of that University, and the title of Professor Emeritus on the occasion of his retirement from the active duties of his Chair in 1909.

Purdie succumbed to heart failure on December 14, 1916, at the age of 73, and was buried in the Cathedral Cemetery of the grey little city which he loved so well, and in which he laboured so long.

P. F. F.

GEORGE BALLARD MATHEWS, 1861–1922.

George Ballard Mathews was born in London on February 23, 1861. His father, George Mathews, was the son of a Herefordshire yeoman farmer, and engaged for many years with a London business house. His mother's maiden name was Harriet Ballard, daughter of George Ballard, secretary to the Board of Inland Revenue, and a remarkable man from whom Mathews inherited much of his personality and intellect. From his mother he inherited his literary and musical abilities, his interest in general subjects, and his powers of calculation.

The family returned to Herefordshire in 1866, and Mathews, in 1872, entered Ludlow Grammar School, where his brilliant intellect soon asserted itself. Records of 1875 state that he was first in the top form with prizes in Mathematics, French, Drawing, Form Prize, and Parents' Prize. During the four years, 1874–78, he was captain of the school. From the Rev. W. C. Sparrow, one of the most successful Headmasters of the school, he received instruction in Hebrew as well as in Greek and Latin.

There followed a year at University College, London, of which body he afterwards became a Fellow, during which he attended Henrici's lectures on geometry, and began to study Sanscrit. In 1879 St. John's College, Cambridge, offered him the senior scholarship of his year in either Mathematics or Classics. Carrying out his intention of reading for the Mathematical Tripos,

he became a private pupil of Mr. W. H. Besant of St. John's. The keen competition for leading places in the Tripos of this period had brought fame to Mr. E. J. Routh as a coach. All the abler candidates went to Routh as a matter of course, for Routh had a long series of senior wranglers to his credit. However, Mathews' name was read out first in the list of 1883, this being the only break in a succession of about thirty consecutive seniors trained by Routh.

In 1884, Mathews was appointed to the Chair of Mathematics in the newly-constituted University College of North Wales at Bangor, and in the same year was awarded a Smith's Prize and a Fellowship at St. John's. His colleagues at Bangor were all of the same generation as himself, and included such men as Profs. Andrew Gray, James Dobbie, and the late Henry Jones, under the leadership of Principal Harry R. Reichel (the last three named have all since been knighted). Writing in 'Nature' (June 3, 1922), of the period which followed, Prof. Gray says: "[Mathews] came full of eager enthusiasm for the teaching of mathematics and for original mathematical work, and for ten years laboured hard in the hope of founding something like a school of mathematical study in North Wales. But, alas! these hopes were dashed. Perhaps he was a little impatient, and I certainly did my best to counsel him to wait, and to find out the effect of the new Welsh University on the studies of the place, but without effect. The best of the Welsh students were at that time attracted by the Neo-Hegelian philosophy, and some of them, as seems to be the way with such students, seemed not a little proud that their mental tendencies were not mathematical. To this curious type of intellectual pride Mathews referred eloquently in the posthumous paper published in 'Nature' of April 22. In that paper, he lamented the revival of the fallacious arguments for the supremacy of the Latin-Greek classics as an educational instrument; but he in no way under-valued classical culture, only he thought that, to an Englishman, the inheritor of a copious and flexible language, and of a literature unparalleled in the past, a training in Latin and Greek was far from indispensable and might have its disadvantages."

The Bangor Chair was resigned in 1896, and shortly followed (1897) by Mathews' election into the Royal Society, on the Council of which he served for a year. He also served on the Council of the London Mathematical Society from 1897 to 1904. Having returned to Cambridge he was appointed University Lecturer in Mathematics, and acted for a year (1904–5) as Mathematical Secretary to the Philosophical Society. The Cambridge appointment, like the earlier one in Bangor, was resigned on account of temperament, and he returned to live in Bangor. Since 1911 he held a special lectureship in the North Wales College, and again acted as Professor there during the two sessions 1917–19. The honorary degree of LL.D. was conferred by Glasgow University in 1915.

While thoroughly familiar with all branches of pure mathematics, Mathews' main interests were in the theory of numbers and projective geometry. The

theory of numbers, which, in its widest sense, is the theory of discrete, as opposed to continuous, magnitude, has passed through four well-defined stages of development. First there came the period of Diophantine Analysis proper, of which the greatest exponents, after Diophantos among the ancient Greeks, were Fermat and Euler. In this, the general problem is to determine all the solutions in rational numbers of a system of $m (< n)$ algebraic equations

$$R_i (x_1, x_2, \dots x_n) = 0, \; i = 1, 2, \dots m.$$

Next came the discovery of the law of quadratic reciprocity which rendered possible a discussion of quadratic arithmetrical forms, so ably expounded by Gauss in the "Disquisitiones Arithmeticæ." Such writers as Lejeune-Dirichlet, Eisenstein, and Stephen Smith added much to what Gauss had done, and a scholarly introduction to the whole theory was given by Mathews in his "Theory of Numbers" of 1892. A problem which arises in the theory of quadratic forms (the determination of the class-number) was the forerunner of the analytical theory which is intimately bound up with certain transcendental functions of a complex variable. This theory, which has recently received much attention from Prof. E. Landau, Prof. G. H. Hardy, and the late S. Ramanujan, had little atraction for Mathews, though his book contains an introduction to it.

The fourth stage was marked by Dedekind's discovery of his theory of ideal numbers, which completely restore to a system of algebraic numbers certain factorisation properties of ordinary integers that appear at first to be lost. Mathews' was probably the first mind in England to realise the far-reaching effect of Dedekind's discovery, two papers by him on the subject appearing in the London Mathematical Society's Proceedings of 1892.

The tract "Algebraic Equations" on a kindred topic, written fifteen years later, contains a masterly exposition of Galois' theory, completed by Jordan and others, showing how the different types of irrationality which can be defined by an algebraic equation are associated with different types of group.

Written in collaboration with Prof. Andrew Gray and mainly concerned with physical applications, the "Treatise on Bessel Functions" (1894) is still a standard work. The "Projective Geometry" (1914), inspired by Henrici's lectures in London many years before, contains two unusual features: first, an exposition of the logical groundwork of the subject; and, secondly, an account of Staudt's theory of complex elements (whereby a real involution defines a complex point or line). Mathews also brought out a new edition (1904) of R. F. Scott's "Determinants," and contributed articles on "Number" and "Universal Algebra" to the 1910 edition of the "Encyclopœdia Britannica."

Most of Mathews' technical papers appeared in the London Mathematical Society's Proceedings, or in the "Messenger of Mathematics." Some of the earliest, beginning in 1886, are connected with Fermat's Last Theorem, a question which absorbed much of his attention at intervals during the rest

of his life. Being firmly convinced of the veracity of Fermat's statement, he tried to approach the problem by such methods as might have been devised in Fermat's day. His last contribution to the subject appeared in a review published in 'Nature' of January 5, 1922.

A few of the earlier papers deal with geometrical subjects, such as twisted quartic curves, geometry on a quadric surface, and porisms. Nearly all the rest have an arithmetical bearing. Several papers discuss points connected with the Gaussian theory of quadratic forms, the subject of his book. In 1892 he wrote on quadratic forms with complex coefficients, a subject to which he returned twenty years later. In early days he corresponded freely with Cayley and Sylvester.

Among the specialised branches of the higher arithmetic Mathews was mainly interested in the complex multiplication of elliptic functions. Being an assiduous disciple of Dedekind and Klein, he fully realised the fundamental character of the absolute invariant $j(\omega)$ and of the type of irrationality involved in it. Papers written in the nineties, when Sir George Greenhill and Mr. Russell were working at the subject too, give special detailed properties of the lemniscate functions. He also showed the significance of Klein's principal moduli and calculated some new class-invariants. Returning to the subject in later years, he produced a fuller manuscript on the lemniscate functions: its publication has been delayed by the war and his subsequent illness.

Ever since the mid-eighties Mathews was a frequent contributor to 'Nature' on mathematical topics. His articles and reviews, most of which appeared over the initials "G. B. M," were always written in a careful and scholarly style; they contained his considered opinion on the book or point concerned. His keen yet kindly criticism was undoubtedly of the greatest service to the many writers whose work passed through his hands. In conversation with the present writer he once expressed the opinion that some of his best work had appeared in 'Nature' reviews.

A man of simple tastes and naturally retiring by disposition, Mathews expressed sound judgment on both men and affairs. Some of his views were those of an idealist and hardly feasible in the domain of practical politics. His capacity for maturely grasping everything with which his mind came into contact made him unique in the experience of his friends. Only one or two sides of so versatile a man's brilliant intellect really appealed to most people. When he was appointed Professor of Mathematics at Bangor, at the age of twenty-three, it was manifest that he could equally well fill four or more chairs in the College. Again, to quote Prof. Gray: "Mathews had a knowledge of Latin and Greek as minute and accurate as that generally possessed by professional classical scholars. He wrote pure and elegant Latin. I remember his amusing himself by turning into Latin prose an original philosophical dissertation which had happened to come into his hands and had arrested his attention. I remember also some Latin verses which he published anonymously, and which were much praised by a very

eminent scholar. He wrote also charming English essays in the style of Charles Lamb, of whom he was a great admirer. These, I fear, are lost, but one of them, 'On a Cock-loft,' was a perfect gem, a charming piece of the most natural and simple prose."

A humorous controversy in Latin Elegiacs between Profs. Arnold and Mathews, in which Mathews did not come off second best, inspired Principal Reichel's epigram, addressed, in the College Magazine, to a mathematical student who had been reading Mathews' verses :—

> Versibus an numeris noster praestantior anceps
> Mattius ; attonito cur puer ore siles ?
> Qui numeros dicit vult idem dicere versus,
> Testibus innumeris, o numerose puer.

In the early days at Bangor Mathews began to learn Arabic, and spent much time of later years in reading and translating Arabic poetry. His translations are full of the spirit of the original lines; it is to be hoped that some of them will be published later.

Mathews' knowledge of music, again, was fully as advanced as that of most professional musicians. His copies of Gauss and Bach were placed together on the same shelf, and he considered some of Sir Edward Elgar's compositions to be as fine as the work of Beethoven and Handel.

Undoubtedly, the strength of his numerous interests prevented him from making the most of his mathematical work. His name will be mainly remembered in connection with the higher arithmetic.

The last three years of his life were clouded by a series of operations for cancer, which finally gained the mastery. He died, unmarried, in a Liverpool nursing home on March 19, 1922.

W. E. H. B.

G. Lippmann

Thomas Purdie